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WATER SUPPLY AND WATER QUALITY STUDY, PAJARO RIVER BASIN, CALIFORNIA. PRELIMINARY REPORT ON FUTURE MUNICIPAL AND INDUSTRIAL WATER USE AND WATER QUALITY CONTROL NEEDS

Public Health Service
San Francisco, California

April 1964

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WATER SUPPLY AND WATER QUALITY STUDY

PAJARO RIVER BASIN

CALIFORNIA

A Preliminary Report on Future
Municipal and Industrial Water Use
and Water Quality Control Needs

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PUBLIC HEALTH SERVICE
San Francisco, California

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April, 1964

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WATER SUPPLY AND WATER QUALITY STUDY

PAJARO RIVER BASIN

CALIFORNIA

PRELIMINARY REPORT ON FUTURE MUNICIPAL AND INDUSTRIAL WATER USE AND WATER QUALITY CONTROL NEEDS

Prepared at the Request of

U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS DISTRICT
San Francisco, California

by

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
REGION IX
PUBLIC HEALTH SERVICE
SAN FRANCISCO, CALIFORNIA

APRIL, 1964

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TABLE OF CONTENTS

	Page No.
LIST OF TABLES	
LIST OF FIGURES	
INTRODUCTION	1
Purpose	1
Scope	1
Authority and Request	1
Acknowledgments	1
SUMMARY AND CONCLUSIONS	
Summary	3
Conclusions	4
DESCRIPTION OF STUDY AREA	
Physical Description	7
Economic and Social Factors	7
HYDROLOGY AND WATER QUALITY	
Surface Water Hydrology	10
Surface Water Quality	10
Ground Water Hydrology	13
Ground Water Quality	13
WATER USE	
Present Withdrawal Users	14
Present "In Place" Water Use	14
Future Withdrawal Use	14
Future "In Place" Water Use	14
WATER QUALITY CONTROL	
Water Quality Criteria	18
Present Sources of Waste Water	19
Future Sources of Waste Water	19
Location of Future Dischargers	20
Water Quality Control Flows Needed	22
Alternate Methods of Future Waste Disposal	25
FUTURE WATER RESOURCE DEVELOPMENT	
Water Quality Considerations	28
Studies by Other Agencies	28
Other Possible Developments	29

Page No.

BENEFIT EVALUATION

Municipal and Industrial Water Supply 33
Water Quality Control 33

BIBLIOGRAPHY 35

APPENDICES

APPENDIX A. WATER USE AND WASTE LOADINGS

APPENDIX B. WATER QUALITY CONTROL FLOWS

APPENDIX C. ESTIMATED COST OF THE LEAST COST ALTERNATIVE METHOD OF WASTE TREATMENT AND DISPOSAL

APPENDIX D. GROUND WATER SALT BALANCES

FIGURES

LIST OF TABLES

Table		Page No.
1.	Pajaro River Basin - Projected Annual Water Use and Additional Development Needed	5
2.	Population Projections - Pajaro River Basin	8
3.	Streamflow and Impoounding Reservoirs, Pajaro River Basin	11
4.	Range and Average of Surface Water Quality in Pajaro River Basin	12
5.	Major Municipal Water Supplies and Waste Treatment and Disposal Systems, Pajaro River Basin	15
6.	Municipal and Industrial Water Use Forecast	16
7.	Urban Waste Load Forecast	21
8.	Projected Water Quality Control Flows, Llagas-Uvas and Hollister-Tres Pinos Sub-basins	23
9.	Proposed Reservoir Development (California State Water Plan)	30
10.	Future Water Uses and Needs in the Pajaro River Basin	34

LIST OF FIGURES

Figure	Page No.
1. Pajaro River Basin Drainage Area	D-5

INTRODUCTION

Purpose

This report presents a preliminary assessment of the need for and value of municipal and industrial (M&I) water supply and storage for flow regulation required for water quality control in the Pajaro River Basin.

Scope

This study considers the present and projected water quality control needs and water use within the Pajaro River Basin. Projections developed from a Corps of Engineers Economic Base Study, are made by 20 year increments to the year 2060. Pollution loads to the stream and/or alternate means of waste disposal are considered in order to determine the extent of water quality management required. Alternate methods of providing M&I water needs are investigated. This study is based on a review and interpretation of available data and reports and limited visual field observations.

Authority and Request

The U. S. Army Corps of Engineers is currently preparing a comprehensive water resource investigation of the Pajaro River Basin. In connection with this study the Public Health Service was asked to cooperate in the study by assessing the water quality control and M&I needs of the basin. In a letter dated April 16, 1963, to the Corps of Engineers, the Public Health Service agreed to prepare a preliminary report. The Study has been made in accordance with: (1) The Memorandum of Agreement dated 4 November 1958 between the Department of the Army and the Department of Health, Education, and Welfare relative to Title III of P.L. 500, 85th Congress, as amended by Public Law 87-88; and (2) Federal Water Pollution Control Act (Public Law 84-660) as amended by P.L. 87-88.

Acknowledgements

Valuable assistance and data for this study were provided by personnel of the following agencies:

U. S. Department of Army, Corps of Engineers, San Francisco Bay District, California.

California State Health Department, Bureau of Sanitary Engineering.

Central Coastal Regional Water Pollution Control Board (#3).

The cooperation, data, and assistance furnished by these agencies is sincerely appreciated.

SUMMARY AND CONCLUSIONS

Summary

1. The pajaro River Basin drains an area of 1300 square miles located in the Coast Range Mountains of California and discharges to the Pacific Ocean near Watsonville, 70 miles south of San Francisco (See Figure 1). Major tributaries in the basin are the San Benito River, Uvas, Pacheco, Tres Pinos, and Corralitos Creeks.

2. The Corps of Engineers project that the Pajaro River Basin will grow from a 1960 population of 60,600 to 851,000 by 2060. Most of the 2060 population (720,000) will be in the Llagas-Uvas Sub-basin but the remainder of the basin is expected to remain agriculturally oriented.

3. The total average annual flow of the Pajaro River Basin is approximately 130,000 acre feet per year (an average of 115 million gallons per day). Over 90% of the run-off occurs during the months of December through May and flow is low or non existent during the summer months.

4. The only significant surface water diversion for municipal and industrial use (approximately 3,000 acre feet per year or 2.6 mgd) is from Corralitos Creek. The amount of surface water diverted for irrigation is negligible.

5. Except for the San Benito River, the average surface water quality is satisfactory for most municipal, industrial, and agricultural uses at the present time. However, during periods of low flow most of the flow is from irrigation return flows, causing dissolved solids, sulfates, and chlorides to exceed the upper limits of the Public Health Service Drinking Water Standards.

6. The safe ground water yield is estimated to be 159,000 acre feet/year (144 mgd). The 1960 annual pumping rate was 182,000 acre feet (161 mgd) causing ground water levels to fall over most of the basin.

7. In 1960 agricultural users pumped 173,000 acre-feet of ground water and municipal and industrial users pumped 9,000 acre feet (8 mgd).

8. Ground water is moderately hard but of satisfactory quality except for an area in the Upper Pajaro Sub-basin where a high boron concentration makes it unsuitable for agricultural use.

9. The feasibility of meeting the expected water needs by multiple purpose reservoir developments within the basin is being studied by the

Corps of Engineers and the Bureau of Reclamation has completed a feasibility report (San Felipe Division) recommending importation of water from the Central Valley Project.

10. Watsonville and surrounding communities discharge treated wastes into the Pacific Ocean through an ocean outfall, while other communities in the basin discharge treated wastes to percolation or holding ponds.

11. There is no significant fishery or recreational use of surface streams.

12. The following possibilities of disposing of the future waste load were investigated:

a. Continued discharge to ponds.

b. Treatment and use of effluent for irrigation

c. Primary treatment and discharge by ocean outfall.

d. Secondary treatment, discharge of effluent to stream, and maintenance of stream quality by adequate quality control releases.

Conclusions

1. Projected gross annual water use and additional water supply needs for the Pajaro Basin are shown in Table 1. Irrigation usage (projected by U. S. Bureau of Reclamation) is shown since it competes with M & I usage for the existing water supply and any increase or decrease will directly influence the need to develop additional M & I water.

2. The present (1960) annual equivalent value of benefits of the additional development for municipal and industrial use is $1,234,000, based on a proposed cost of $30 per acre foot for importing water from the Central Valley Project, which is the most likely, least coast alternative to development within the Pajaro River Basin.

3. There is no anticipated need for storage to provide for water quality control in the Upper Pajaro, Pajaro Valley, or Upper San Benito Sub-basins.

4. In the Llagas-Uvas and Hollister-Tres Pinos Sub-basins a large quantity of water, 100,000 acre feet by 2060, would be required to maintain water quality if wastes are discharged to the Pajaro River. The reach of river between the point of maximum waste discharge and entry to Monterey Bay is about 25 miles long and the

TABLE 1

PAJARO RIVER BASIN

PROJECTED ANNUAL WATER USE AND
ADDITIONAL DEVELOPMENT NEEDED

	Municipal and Industrial			Agriculture	
		Use	Need	Use	Need
Year	(mgd)	(1000 ac-ft/yr.)	(1000 ac-ft/yr)	(1000 ac-ft/yr.)	(1000 ac-ft/yr)
1960	11	12	0	173	23
1980	32	36	24	234	84
2000	60	68	56	201	51
2020	94	105	93	188	38
2040	125	141	129	188	38
2060	142	160	148	188	38

projected downstream supplemental needs are only 77% of the projected water quality control releases in the year 2000 and decrease to 37% in 2060. The possibilities of enhancing fishery and recreational uses appears limited.

5. It is concluded that discharging wastes through an ocean outfall is the ultimate plan that will involve the least treatment and disposal costs and also allow optimum beneficial use of water resources developed for the Pajaro Basin.

6. Under some conditions, a temporary surplus of water may make waste discharge to streams with provision of water quality control flows a reasonable interim solution or partial method of disposal. Any specific project proposal in the Parjaro River Basin should be reviewed for possible inclusion of water quality control storage.

7. The total dissolved solids (TDS) concentration in the ground water of the Llagas-Uvas and Hollister-Tres Pinos Sub-basins is likely to increase if there is increased percolation of irrigation water and continued heavy pumping from the ground water table.

8. A surface water supply should be developed for M & I use only if the quality after adequate treatment meets the Public Health Service Drinking Water Standards.

9. Water resource development and waste water reclamation or disposal plans (for both surface and underground development) for the entire Pajaro Basin should be coordinated since development plans could be incompatible with certain disposal or re-use schemes.

DESCRIPTION OF STUDY AREA

Physical Description [1/]

The Pajaro River Basin drains an area of 1300 square miles located in the Coast Range mountains of California, and empties into the Pacific Ocean in Monterey Bay near Watsonville. The northern boundary lies about 60 miles south of San Francisco and extends for another 88 miles in a southeasterly direction, paralleling the California shoreline with the main portion of the basin inland from the coastline, as shown in Figure 1. About 25 percent of the area (broad, flat valleys) is under cultivation and 47 percent is range land. The Basin lies in four counties: Santa Clara, Santa Cruz, San Benito and a small portion of Monterey.

The climate of the Pajaro Basin is characterized by cool and moist winters with warm and dry summers. About 93 percent of the basin precipitation occurs during November through April. Annual precipitation varies from 13 to 44 inches within the basin, with a 19 inch average. Snow is rare in the basin.

Economic and Social Factors

The Pajaro River Basin supported a population of about 60,600 people in 1960. The Corps of Engineers has identified 5 sub-basins (see Figure 1) and projected the 100 year population for each basin. These projections are shown in Table 2.

The Llagas-Uvas Sub-basin economy is based mainly on agriculture at the present time. This area is projected to grow much faster than the other sub-basins as a result of the southward expansion of the San Jose area (south edge of San Francisco Bay). The agricultural enterprise will gradually be displaced by manufacturing and service industries during the next fifty years.

In the Pajaro Valley sub-basin agriculture and food processing is expected to remain an important industry. The Hollister-Tres Pinos sub-basin will continue to be an important agricultural area. Irrigated significantly but the population is projected to increase by less than 2000 people. The Upper San Benito sub-basin is a hilly region with a sparse population which is projected to increase by only 800 persons in the next 100 years.

The Corps of Engineers (1) concludes, "It is probable that ultimate development will occur in the Llagas-Uvas and Pajaro well within a hundred years. In the remainder of the basin, particularly in the less hilly portions, agriculture will be carried to the ultimate level of development under forseeable market conditions and agronomic

TABLE 2

POPULATION PROJECTIONS

PAJARO RIVER BASIN

Sub-basin	Population		
	1960	2000	2060
Llagas - Uvas	26,400	251,000	720,000
Pajaro Valley	21,000	73,000	94,000
Upper Pajaro	2,100	3,000	4,000
Hollister - Tres Pinos	10,300	18,800	31,400
Upper San Benito	800	1,200	1,600
Basin Total	60,600	347,000	851,000

Source: U. S. Army Corps of Engineers, San Francisco District Office, Pajaro River Basin - Economic Base Study, June 1963.

techniques. In those portions of the basin which remain essentially agricultural, urban communities will expand, but urban development will fall considerably short of the potential carrying capacity of the land."

HYDROLOGY AND WATER QUALITY

The principal source of water supplies is ground water. Reservoirs have been developed to impound surface waters for re-charge to the ground water basin. The ground and surface water resources of the Pajaro Basin have been studied recently by the U.S. Bureau of Reclamation in connection with their proposed San Felipe Project which would import water from the Central Valley to the Llagas-Uvas, Upper Pajaro, Hollister-Tres Pinos, and Pajaro sub-basins as well as to the South San Francisco Bay area.

Surface Water Hydrology

Average yearly runoff (not corrected for upstream diversions) of the Pajaro River at Chittenden, California is 109,300 acre feet. There is an additional runoff of about 21,000 acre feet/year from streams in the Pajaro Valley Sub-basin (below Chittenden). Annual recorded runoff and existing reservoir capacity for the basin is presented in Table 3. The existing reservoirs are operated as flood control and water conservation reservoirs which store runoff for ground water recharge. Table 3 illustrates the extreme variability of annual surface flows. Flows are also highly seasonal with over 90% of the annual runoff occurring during the months of December to May. The lower reaches of the Pajaro River rarely become dry but flows below 1.0 cubic feet per second (cfs) occur for extended periods in approximately one year out of three. Tributary streams are usually dry for extended periods during the summer and fall.

Surface Water Quality

Mineral content of surface waters in variable depending on the vegetation, geology and agricultural activity in the individual sub-basins. Uvas and Llagas Creeks have water of generally good mineral quality while San Benito River water is highly mineralized (see Table 4). The Pajaro River originates at San Felipe Lake which is supplied primarily by Pacheco Creek. There are also return irrigation flows along the Pajaro, mostly from the north (Llagas-Uvas Sub-basin). The quality of Pajaro River water at Chittenden represents a mixture of these streams and the mineral concentration is higher during periods of low flow. During periods of low flow the concentration of TDS, chlorides, and sulfates often exceed upper limits for drinking water as set forth in the USPHS Drinking Water Standards. Streams in the Pajaro Valley sub-basin have mineral quality comparable to the Llagas-Uvas sub-basin. It is believed that irrigation return flows are the major source of quality impairment in the Pajaro River Basin (2).

TABLE 3

STREAMFLOWS AND IMPOUNDING RESERVOIRS
PAJARO RIVER BASIN

STREAMFLOWS

Gaging Station Location	Drainage Area in Square Miles	Annual Runoff in Acre-feet (water years) Maximum	Minimum	Average	Period of Record
Pacheco Creek Near Dunneville	146	76,430	0	25,050	10/39-9/61
Llagas Creek Near Morgan Hill	14.6	24,180	719	10,210	10/51-9/61
Uvas Creek Near Morgan Hill	30	68,000	1,970	24,600	10/30-4/57
San Benito River Near Willow Creek School	250	91,560	1,180	17,475	10/39-9/61
San Benito River Near Hollister	586	107,100	101	22,190	10/49-9/61
Pajaro River at Chittenden	1,188	446,300	3,030	109,300	10/39-9/61
Corralitos Creek at Freedom (1)	27.8	23,540	367	7,820	10/56-10/62

IMPOUNDING RESERVOIRS

Name	Stream	Size (capacity) (Ac.Ft.) (2)	Operator
North Fork Reservoir	Pacheco Cr.	6,150	Pacheco Pass Water District
Chesbro Dam	Llagas Cr.	7,500	South Santa Clara Water Conservation District
Uvas Dam	Uvas Cr.	10,000	South Santa Clara Water Conservation District
Paicines Dam	San Benito R.	3,500	San Benito County Flood Control & Water Conservation District
Hernandez	San Benito R.	18,700	San Benito County Flood Control & Water Conservation District
College Lake	Salsipuedes Cr.	3,600	Privately owned

Sources: U. S. Geological Survey Surface Water Records; and Bradberry, C.E. "Memorandum Report Pajaro River Watershed," June 1963.

(1) Maximum and Minimum annual runoff is for calendar years on Corralitos Cr.

(2) Reservoirs smaller than 3,000 acre feet are not listed.

TABLE 4

RANGE AND AVERAGE OF
SURFACE WATER QUALITY IN PAJARO RIVER BASIN

	Pajaro River (Chittenden)		San Benito River (Bear Valley School) (2)		Uvas Creek (Near Morgan Hill)		USPHS (3) Drinking Water Standards
	Range	Average (1)	Range	Average (1)	Range	Average (1)	
Specific Conductance micromhoes @ 25°C	262 - 2150	410	686 - 2270	1050	176 - 480	230	
Total Dissolved Solids	160 - 1360	225	420 - 1380	640	110 - 290	140	500
Hardness (Total)	102 - 647	160	298 - 715	420	76 - 230	110	
Sodium	15 - 306	26	40 - 278	96	6.0 - 16	7.1	
Chloride	12- 382	24	18 - 260	60	3.2 - 11	5.5	250
Nitrate	0.7 - 12	11	0.2 - 1.6	0.3	0 - 1.6	0.8	45
Sulfate	138 - 264	180	72 -484	330	15 - 40	22	250
Turbidity	1 - 240	180	1 - 400	61	1 - 90	30	
Boron	0.0 - 2.2	0.2	0.4 - 2.6	0.9	0.0 - 0.2	0.04	
PH (units)	7.4 - 8.4	7.5	7.9 - 8.6	8.4	7.3 - 8.4	7.7	
Dissolved Oxygen, winter summer	7.6 - 12.8 7.3 - 11.8	9.4 9.1	8.5 - 12.4 8.4 - 12.7	10.2 9.5	9.2 - 13.5 7.2 - 11.8	11.1 10.5	
Temperature, winter Of summer	45 - 63 57 - 73	57 67	46 - 83 63 - 89	59 77	47 - 70 61 - 79	58 70	
Coliform, MPN/ml	0.62->7,000	23	0.62-2400	2.3	0.06-620	6.2	

Source: Monthly reports by California Department of Water Resources of the period 1/60 - 8/63.

(1) Average values were computed by dividing the summation of concentration X flow for each sampling day by the summation of flows on each sampling day. However, the values listed for Temperature, D.O., and Coliform are median values rather than averages. All values are in milligrams per liter (mg/l) unless stated otherwise.

(2) Actually location of station is near Bear Valley Fire Station, about 5 miles upstream from Willow Creek School gaging station.

(3) The concentrations of chemical substances should not exceed these concentrations where, in the judgement of the Certifying Authority, other more suitable supplies are or can be made available.

Organic quality in Pajaro River Basin streams is satisfactory at the present time. Dissolved Oxygen levels are invariably above 75% of saturation and are often supersaturated. No significant quantities of sewage or other organic wastes are routinely discharged to the streams at this time.

Ground Water Hydrology

Present yield estimates of the ground water resources of the Llagas-Uvas, Upper Pajaro, part of the Hollister-Tres Pinos, and the Pajaro Valley (Watsonville) sub-basins are presented in Table 10 (page 35). These basins are presently being overpumped, resulting in a gradually lowering water table (3).

There is little information on ground water hydrology in the Upper San Benito Sub-basin. However, extensive development for local needs will not be needed and it is unlikely that there are sufficient quantities available to be of value to the rest of the Pajaro Basin.

Ground Water Quality 4/

The ground water quality can be described as generally satisfactory for the three principal valley area, with particular descriptions as follows:

1. Llagas-Uvas (South Santa Clara Valley) Sub-basin. Total dissolved solids of aquifers average about 250-550 mg/l, moderately to very hard and typically of calcium-magnesium or magnesium-calcium bicarbonate type. Chlorides range from 10 to over 100 mg/l with boron below 0.4 mg/l.

2. Upper Pajaro and Hollister-Tres Pinos (North of Tres Pinos Creek) Sub-basin. The principal aquifers in this area produce water of acceptable irrigation quality, with considerable variation of different dissolved solids consituents. An area of high boron content water is found east of Hollister and this water is not suitable for irrigation. The semiperched or perched water in the Upper Pajaro sub-basin is high in salt concentrations and also not used for irrigation.

3. Pajaro Valley (Watsonville) sub-basin. There are 3 zones of ground water in the area. The shallow zone is often of poor water quality. The intermediate zone water is generally of good to excellent water quality, moderate to very hard, with limitations on some uses. The limited data on the deep water indicate that it has excellent mineral quality. Sea water intrusion has occurred in wells near Monterey Bay but it can probably be repelled by about 2,000 acre feet per year of recharge water.

WATER USE

Present Withdrawal Users

1. Municipal and Industrial Water Supplies.. Most M & I water supplies are obtained from deep wells. Chlorination or no treatment is the usual practice. Watsonville, which is the only community using surface water, provides treatment by sedimentation, slow sand filtration and chlorination. Present municipal water supplies and waste treatment and disposal systems are described in Table 5. Current M & I and agricultural usage is shown in Table 10.

2. Agricultural Water Use. Virtually all irrigation water is derived from wells. The totals presently pumped are shown in Table 10. The fraction of pumped water used for agricultural in the various sub-basins varies from 88 to 99 percent.

Present "In Place" Water Use

Present "in place" use of the Pajaro River Basin streams is small and there are no significant water based recreation sites. The tributary streams provide limited fishing and summer "swimming holes."

Migratory fish (steelhead trout) use the stream during years of high-runoff and spawn in Uvas Creek. The size of this run is undetermined. Releases for percolation from Uvas Reservoir are operated to provide water for fishery enhancement (20 cfs in winter and 10 cfs rest of year if the water is available) (5). A run of striped bass has recently developed in the Pajaro River during the spring months.

A warm water fishery is available at several lakes and reservoirs in the basin. The summer fishery in the basin streams is small.

Future Withdrawal Use

Future gross withdrawal estimates for municipal and industrial water supply are shown in Table 6 for the period of 1960-2060. The forecasting method and data used are shown in Appendix A. Projections for total water use (including irrigation projections supplied by Bureau of Reclamation) are shown in Table 10.

Future "In-Place" Water Use

The U. S. Fish and Wildlife Service has recommended the establishment of a warm water fishery in Chesbro and Uvas Reservoirs

TABLE 5

MAJOR MUNICIPAL WATER SUPPLIES
AND WASTE TREATMENT & DISPOSAL SYSTEMS
PAJARO RIVER BASIN

Area Served	Population Served (Thousands)	Water Supplies			Waste Treatment & Disposal	
		Per Capita Use Gallons/day	Type of Treatment	Source	Type of Treatment	Discharge To
Freedom	2.8	--	---	City of Watsonville	City of Watsonville	----
Gilroy	8.2	145	None	4 wells	Primary	Percolation ponds, overflow to Uvas Creek
Hollister	7.0	145	Chlorination	2 wells, 1 infiltation gallery	Imhoff Tank	Percolation ponds (1)
Hollister-Sunnyslope W.C.	0.9	135	None	1 well	----	----
Morgan Hill	3.2	155	Clorination, fluoridation	4 wells, 1 spring	Secondary (trickling filter)	Percolation ponds
Pajaro	1.5	--	---	City of Watsonville	City of Watsonville	(2)
San Juan Bautista	1.1	105	Chlorination	2 wells, 1 infiltration gallery	Secondary(trickling filter)	Percolation ponds
San Martin	1.2	--	Chlorination	well	Primary	Percolate to ground
Watsonville	23.2	86	Sedimentation, filtration, chlorination	9 wells, 2 streams	Percolation, Primary, chlorination	Pacific Ocean

Sources: California State Health Department, Central Coastal Regional Water Pollution Control Board, and USPHS data.

(1) A vegetable processing plant has separate system with ponds in dry river bed.

(2) The Town of Pajaro can bypass sewage to Pajaro River.

TABLE 6

MUNICIPAL & INDUSTRIAL
WATER USE FORECAST

(Million Gallons per Day)

Area	1960	1980	2000	2020	2040	2060
Llagas-Uvas	4.3	16.9	40.1	69.4	97.7	111.2
Pajaro Valley	4.3	11.6	16.0	18.6	20.5	23.1
Upper Pajaro	0.3	0.4	0.6	0.6	0.7	0.8
Hollister-Tres Pinos	1.9	2.5	3.8	4.6	5.8	6.7
Upper San Benito	0.1	0.2	0.2	0.2	0.3	0.3
Totals*	10.9	31.6	60.7	93.4	125.0	142.1

*Totals are rounded to the nearest 0.1 mgd.

but have not requested minimum stream flows for fishery enhancement. Even under present stream conditions of erratic flow and shallow depth the amount of fishing and swimming in the streams will probably increase due to the increased population, although the quantity of fish and suitable swimming locations are limited. Future water quality control flows, if provided, would undoubtedly increase the fish runs and may provide more suitable swimming locations (although the use of waters containing such a high percentage of sewage effluent is not presently acceptable to local health and regulating authorities). Benefits to enhancement of recreation should be reviewed if water quality control flows are provided.

WATER QUALITY CONTROL

Water Quality Criteria

The desired quality of a water depends on its anticipated use. Irrigators, fishermen, swimmers, and M & I users all have differing water quality needs. Measures of water quality which should be considered are the concentration of: minerals (natural or man caused), nutrients, pesticides, radioactivity, coliform bacteria, and organic pollution. Pollution from domestic wastes will be of primary concern in the future since current surface water quality is acceptable and future changes will be primarily due to this type of pollution.

Experience indicates that for man-made pollution from domestic type wastes on flowing streams the bacteriological and organic pollution is critical. Bacteriological pollution should be controlled by adequate disinfection at the waste source and not by dilution. The effect of organic pollution on the dissolved oxygen concentration will be used to determine the magnitude of water quality control flows needed.

The biochemical oxygen demand (BOD) is a measure of the strength of organic pollutants and it can be used to predict the dissolved oxygen (DO) concentration that will occur in the receiving stream. Fish are critically affected by low DO concentrations and it is generally accepted that if the DO level is high enough for fish life and the water is properly treated it can be used for human consumption although it is not good practice to supply M & I water containing large quantities of sewage effluent (regardless of the degree of sewage and water treatment) when better sources are available. A minimum DO level of 5.0 mg/l in California Coastal Streams is considered acceptable by the Public Health Service (California regulatory agencies also use 5 mg/l) and this is the criterion on which projected water quality control flows are based. Maintaining this level of DO would also protect the limited fishery that exits in the streams.

The mineral concentration in the Pajaro River is high during periods of low flow but there are no known users because of this small and irregular flow. Withdrawal from the river would not be practical unless there were extensive water resource developments that would place a much larger quantity (5-40 times the summer flow) of water in the stream. The mineral quality of this developed water (from either Pajaro River tributaries or importation) would be satisfactory at all times. It is concluded that if sufficient water is placed in the stream for withdrawal uses to develop, there will be no need for additional water quality control releases to dilute mineral concentration.

Present Sources of Waste Water

Watsonville and several nearby towns discharge their wastes to the Pacific Ocean. Most other communities give primary treatment and discharge to percolation ponds which are often near (or in) the normally dry stream beds and may be washed out in periods of high flow. Much of the excess irrigation water returns to the ground water basin although some does return to surface streams. Present sources of municipal waste discharges are summarized in Table 5.

Future Sources of Waste Water

The expected population growth in the Pajaro River Basin will develop from an overflow of population from the Bay area and diversification of the basin industry from a primarily agricultural base to a mixture of agricultural processing and light manufacturing augmented by an increase in service industries.

No unusual growth in industrial waste loadings is expected. The proportion of industrial wastes in the overall waste is expected to decrease.

The Bureau of Reclamation proposes to increase both the irrigated acreage and the quantity of irrigation water used in the Upper Pajaro sub-basin by importing additional water to the Pajaro Basin. Some of the return irrigation water in this area enters the streams and is believed to be the cause of the degraded water quality which occurs during the late summer periods of low stream flow. An increase in irrigated acreage south and southeast of the Pajaro River would undoubtedly increase the quantity of degraded water returning to the streams but would not necessarily increase its concentration since much of the present stream flow in late summer and early fall is from return irrigation water. The limited data available makes it impossible to quantitate the affects of increased irrigation.

Irrigation and M & I water which is percolated to the ground water table should be considered as a waste discharge since it can increase the concentration of organic and inorganic materials in the ground water. TDS concentration is usually of most concern although pesticides, nutrients, percent sodium, and individual cations and anions could also be a problem. TDS concentrations can be increased either by reducing the amount of water in ground water storage with the tons of solids remaining constant or by applying more tons of solids than are removed with the volume of water remaining constant. Limited records available indicate that there is a slight increase in TDS concentration in the Llagas-Uvas, Upper Pajaro, and Hollister-Tres Pinos sub-basins under present conditions and that the water table is dropping slightly. Any plan of development which increases the

quantity of importation and does not increase the tons of solids moving out of these sub-basins will increase the TDS concentration since there would be additional tons of solids carried into the ground water aquifer by the percolated import water. Natural outflow from these sub-basins is limited to surface flow in the Pajaro River. It is only during very wet years that the ground water table is high enough to return some flow to the river and the quantity of water involved seems to be somewhat less than 5,000 acre feet per wet year. The expected increase can be calculated by means of a "Salt Balance." (6) A sample determination is shown in Appendix D. The values used for TDS concentration were taken from limited data and the degree of accuracy in the final results is uncertain. However, these computations support the theory that salt concentrations are likely to increase in these sub-basins.

Future urban waste load estimates in pounds of 1st Stage BOD/day are shown in Table 7. The assumptions and computations are shown in Appendix A.

Location of Future Discharges

Projected future waste loadings have been developed and characterized for the several sub-basins. These wastes will be described under the appropriate sub-basin headings.

1. Pajaro Valley. This sub-basin is expected to retain its agricultural character but with more dense residential development. Existing food packaging industries with typically low strength wastes may be combined with increased canning and freezing works. No change in the combined waste strength is projected. A five fold increase in total waste loading and volume is projected during the hundred-year study period.

Treatment facilites for this area are expected to follow the present pattern. Currently the bulk of the municipal and industrial wastes are conveyed to a primary treatment plant west of Watsonville and the effluent is discharged through a submarine outfall into Monterey Bay.

2. Llagas-Uvas. Intensive urbanization is forecast for this area. The towns of Morgan Hill, Gilroy and the surrounding area are linked with the rapid residential growth of Santa Clara County. Agricultural activities are destined to drop sharply and heavy indistries are expected to grow somewhat and then decline as the area becomes saturated with residential developments. A twenty fold increase in waste loading is anticipated within the study period. Water use and waste volume projections are even higher. Total waste concentration are expected to be more dilute as intensive residential development is realized.

TABLE 7

URBAN WASTE LOAD FORECAST

(lb/day - 1st Stage BOD)

Area	1960	1980	2000	2020	2040	2060
Llagas-Uvas	12,000	45,000	100,000	170,000	230,000	251,000
Pajaro Valley	9,100	24,000	33,000	36,000	39,000	40,000
Upper Pajaro	820	1,000	1,400	1,600	1,800	1,900
Hollister-Tres Pinos	5,600	7,800	11,000	14,000	17,000	18,000
Upper San Benito	260	330	460	520	580	600
Total*	27,800	78,000	145,900	222,100	288,400	311,500

*Totals have been rounded to the nearest 100 pounds/day.

[1] This is load during season when food processing is occuring. Projected off-season loads are shown in Table A-4.

At present most waste disposal is by percolation to the ground. A problem already exists at Gilroy where the percolation beds are overloaded and the increasing population in this basin is going to force a change in disposal methods. Possible alternatives for future disposal are discussed in section F.

3. Upper Pajaro. No intensive municipal or industrial growth is forecast in this sub-basin. The hilly region will remain partly agriculture, particularly orchards, and largely undeveloped watershed. Individual waste disposal practices will probably follow present land disposal methods. Increased irrigation in the valley portion of the sub-basin could result in large quantities of degraded return irrigation water entering the Upper Pajaro River.

4. Hollister-Tres Pinos. Forecasted growth within this area is primarily agriculturally oriented with increased food processing industries as a large waste source. The residential and associated municipal growth rate is fairly high in the vicinity of Hollister. Waste treatment, which is currently through percolation of treated sewage will require expansion and some changes in practice. Increased return irrigation flows will probably result if additional acres are irrigated. The irrigation demand in this sub-basin may encourage use of treated sewage for irrigation, although return flows from these wastes may still need to be removed from the basin.

5. Upper San Benito. This area is not expected to grow to any extent and waste disposal practices are not expected to cause any basin-wide problems. Turkey ranching, dry farming and irrigated farming are expected to continue.

Water Quality Control Flows Needed

Water Quality control flows will be needed for the Llagas-Uvas, Upper Pajaro, Pajaro Valley, and Hollister-Tres Pinos sub-basins if municipal and industrial wastes are discharged to the streams. In the year 2000 the Llagas-Uvas sub-basin is predicted to have 84% of the total population and 81% of the total waste load in the Pajaro Basin. The feasibility of providing water quality control flows from Llagas-Uvas and Hollister-Tres Pinos Sub-basins was considered.

The flows necessary to maintain a minimum DO level of 5.0 mg/l in the stream are shown in Table 8 and the method of calculation is described in Appendix B. A treatment efficiency of 90% BOD removal was assumed because other California cities with cannery wastes and minimum stream dilution available have proved this is attainable. Storm water runoff is rarely a problem during the season of peak waste loads.

TABLE 8

PROJECTED WATER QUALITY CONTROL FLOWS
LLAGAS-UVAS & HOLLISTER-TRES PINOS SUB-BASINS

Year	90% BOD Removal		
	Gross Flows[1] (mgd)	Net Flows Ave. mgd	Annual Draft on Storage[2] Acft/Yr
1980	19	22	18,000
2000	43	47	39,000
2030	87	94	79,000
2060	110	120	100,000

[1]Average total flow need for dilution (does not include volume of waste water).

[2]This is amount of water which would have to be provided by resource development, assuming that natural flow in the Pajaro will not be reduced by upstream development, nor increase due to additional agricultural return flows.

The magnitude of the required flows must be considered in relation to the average flow of the Pajaro River. From 1939 to 1962 the quantity of water passing the Chittenden Gaging Station on the Pajaro averaged 109,300 acre feet per year, which is equivalent to 97.5 mgd for the entire year. The average flow would decrease in the future if more extensive use is made of impounding water for ground water recharge (the San Felipe plan would reduce estimated outflow to 81,000 acre feet/year at Chittenden). The amount of water that must be provided in the year 2000 (assuming 90% treatment and all of the water taken from ground water or imported water) is estimated at 48,000 acre feet. In the year 2060, 123,000 acre feet of water would have to be provided. The annual draft on storage would be 39,000 and 100,000 acre feet/year assuming that natural flows (and present irrigation return flows) in the Pajaro Basin are not altered. Of course, present flows could be either increased by more return irrigation water or decreased due to upstream impoundments. It is possible to get better than 90% treatment for BOD removal but it would not be safe to count on this because the concentration of conservative contaminants (such as nutrients and other mineral constituents) in the sewage is then likely to become critical. About 15 percent of the total treated BOD load would be added by the Pajaro Valley Sub-basin. Thus, almost one-half of all the surface water flowing past Chittenden would be needed for quality control flows in the year 2000 and prior to 2060 all of the available surface water would be needed. The Pajaro flows would have to be strictly controlled by impounding reservoirs in order to utilize the limited amount of water available for water quality control flows and eventually some import water would have to be used for this purpose.

At this time there are no significant downstream water users and there may not be any in the future since present plans for supplying future needs are considering either importation of development of water conservation storage on turbutary streams. The present value of the fishery is small and it is not known to what extent it can be enhanced by providing year-around flows at 5 mg/l DO concentration.

There is a need for additional development in the Pajaro Valley and lower parts of the Hollister-Tres Pinos Sub-basins of 30,000 acre feet/year by 2000 and 37,000 acre feet/year by 2060. These needs may be met by proposed developments, which do not consider the Pajaro River. If water quality flows are provided it will be necessary to release 39,000 acre feet dilution water in the year 2000 and 100,000 acre feet in 2060. Furthermore, it is not desirable to furnish municipal users with water that is 45% treated sewage when better sources are available. If water resources development projects create a surplus of water in the early years of the project there may be short terms advantages to providing water quality control flows and disposing of some of the Llagas-Uvas and Hollister-Tres Pinos wastes to the Pajaro River for withdrawal by agricultural users in the Pajaro Valley and lower Hollister-Tres Pinos Sub-basins. However, since the projected agricultural needs in the sub-basins or origin exceeds the expected quantity of effluent available, the overall advantages of this plan are not apparent.

Due to these uncertainties, it appears that the primary benefits, if any, of stream flow regulation would result from savings in the cost of waste treatment and disposal. Alternate methods of waste disposal are discussed below.

Alternate Methods of Future Waste Disposal

1. Several alternative methods of future waste disposal are available in one or more of the sub-basins.

   a. Ocean disposal after at least primary treatment may be accomplished with a large pipeline and ocean outfall.

   b. A high degree of treatment may be provided with discharge to a stream bed. Supplemental stream flows would be required for waste assimilation during all but high run-off periods.

   c. Land disposal with irrigation application or percolation beds may be practical in areas less densly settled and where sufficient agricultural acreage is available.

   d. Individual treatment and disposal (such as septic tanks) may be practical in the more sparsely settled areas.

   e. Exportation of treated wastes to areas requiring agricultural water could become feasible as the cost of irrigation water rises. Return flows from these uses may still need to be piped out of the basin.

2. One or more of these schemes may be economically feasible within a sub-basin. Where the choice is not obvious a cost study was initiated to determine the most appropriate method of waste disposal. Each sub-basin is discussed separately below.

   a. Pajaro Valley. Present waste disposal practice is ocean disposal. Prior to construction of a workable ocean disposal system the Pajaro River estuary and nearby ocean waters was contaminated. Local Pismo clams contained high bacterial concentrations, and steelhead trout kills occurred near the river mouth.

      The construction of the Watsonville municipal and industrial waste primary treatment plan ocean outfall improved the Pajaro River estuary and nearby ocean beach area. This plan serves the nearby communities of Freedom and Pajaro as well.

      The present system of ocean discharge appears to be the best solution for the future. It may be desirable

to subject some of the waste water to secondary treatment and use it for irrigation (7). The reclaimed water which is not used consumptively during irrigation would either percolate to the ground water basin (if applied in the unconfined zone) or return to the streams in this sub-basin. That water returning to streams would be rich in nutrients and could cause algae problems in the Pajaro estuary during periods of low flow.

b. Llagas-Uvas. Waste disposal within this sub-basin will require modification as projected population growth is realized. All of the alternative schemes warrant study, except for individual treatment and disposal. Methods which requires year round exportation or reclaimed waste waters for agricultural use assumes water costs become high enough to warrant the construction of transport structures and waste drains.

Reuse of urban waste water (from this and the Hollister-Tres Pinos sub-basin) for irrigation would increase the quantity of water available. This could, however, cause ground water quality problems since there is a significant TDS build up resulting from M & I water use and at the present time there is no practical way of removing these solids from water. Therefore, re-used water would further increase the adverse salt balance if it is allowed to percolate to the ground water table or increase TDS in surface waters if it is released to the streams without providing water quality control flows. Furthermore, care must be taken to avoid chemical or bacteriological contamination of ground waters which supply M & I water.

Some irrigation return water may need to be carried out of the basin eventually to keep the TDS concentration of ground water from building up. This could be done via a common pipeline along with sewage disposal or it could be discharged to the Pajaro River (if an investigation indicates that percolation rates along this reach of the River are negligible) provided no downstream diversion or impoundment of water during the irrigation season is planned.

C. Hollister-Tres Pinos. The population projections for this sub-basin are low enough so that land disposal may continue to be economical in the future. However, extensive percolation of sewage effluent could cause public health problems if municipal water is to be pumped from nearby wells. It also appears that some wastes (either municipal or agricultural) will have

to be removed from the sub-basin to prevent TDS concentrations from increasing. For these reasons it was assumed that municipal wastes would be removed from the basin either by pipeline of by dilution with water quality control flows.

FUTURE WATER RESOURCE DEVELOPMENT

Water usage in the Upper San Benito sub-basin is expected to increase only a few hundred acre feet in the next 100 years and there should be no problem in developing the needed water from local sources. The other sub-basins will need somethat more water than is presently developed. Import water will definitely be needed in the future to meet project needs, especially in the Llagas-Uvas (where predicted M & I usage in 2060 will be 57,000 acre feet/year more than the present safe annual ground water yield) and Upper Pajaro sub-basins. Projected needs are less in the Pajaro Valley and Hollister-Tres Pinos sub-basins and might be satisfied in large measure from local surface sources.

Water Quality Consideration

Average water quality of the Pajaro River at Chittenden is satisfactory for M & I use (although it is highly mineralized during periods of low flow) since the overwhelming majority of runoff occurs during periods of high flow when the mineral content is low. The San Benito River is more highly mineralized than the Pajaro and its average quality is marginal, with the concentration of sulfates and TDS being higher than that suggested by the USPHS Drinking Water Standards for use when other supplies are available. Water from Uvas Creek and Corralitos Creek is of very good quality.

From a water quality aspect it would be preferable to maximize use of tributaries such as Uvas and Corralitos Creek, and to use San Benito water, if at all, only for mixing with better quality water. It might be advantageous to avoid impounding water on the main stem of the Pajaro so that the river could be used to convey irrigation return flows without impairing M & I water quality. Average water quality for three of the four streams is summarized in Table 4.

Studies by Other Agencies

The Bureau of Reclamation plan calls for a delivery to the Llagas-Uvas, Upper Pajaro, Hollister-Tres Pinos, and Pajaro Valley sub-basins of 31,000 acre feet/year in 1970 and increasing to 106,000 acre feet/year in 2020. The import water would be used as a surface supply and as a means of increasing ground water yield (by increased percolation of excess irrigation water and conveyance system losses) but no use of in-basin surface water is anticipated except for the 3,000 acre feet/year presently used by the City of Watsonville.

If the Bureau's plan is adopted in its entirety water needs will be satisfied until about 2020 for the entire Pajaro Basin (since the Upper San Benito sub-basin is not expected to have water problems). However, water would be needed in increasing amounts after 2020 unless there is a compensating decrease in agriculture use or an increase in water reuse.

The California State Water Plan considered development of about 30,400 acre feet/year of new yield to satisfy present and ultimate conditions in the basin but still believed that import water would be necessary in the Upper Pajaro, Pajaro Valley, and Llagas-Uvas sub-basins. A description of the proposed reservoirs is shown in Table 9.

The Corps of Engineers has studied Corralitos and Salsipudes Creeks in the Pajaro Basin for possible multipurpose reservoir sites. An additional yield of about 6,500 acre feet/year can be developed on Corralitos Creek and College Lake could be enlarged to yield several thousand acre feet/year.

Other Possible Developments

A brief examination was made of other possible reservoir sites in the basin. Coast estimates were not made nor were yields figured in any detail. There are a number of locations where some water could be conserved and this discussion is not meant to be all inclusive but rather to indicate that possibilities do exist for development. This study was oriented toward examining the possibility of first developing water to meet all needs of the Pajaro Valley sub-basin, then to provide as much of the needs of the Hollister-Tres Pinos sub-basin as possible and finally to determine to what extent the needs of the Upper Pajaro and Llagas-Uvas Sub-basins could be developed or imported in each sub-basin by 1980, 2020, and 2060 are given in Table 10.

1. Pajaro Valley Sub-basin. This sub-basin will need an additional 22,000 acre feet/year in 1980 and 26,000 acre feet/year in 2060. Since the average annual runoff of tributary streams in the sub-basin is over 20,000 acre feet (3,000 acre feet is presently being used by Watsonville) and the Pajaro River mean annual discharge is about 109,000 acre feet/year the feasibility of economically developing these supplies should be seriously considered prior to importing water from outside the sub-basin.

One approach would be to develop an additional 6,000 - 12,000 acre feet/year on Corralitos and Salsipuedes Creeks. Then the additional 10,000 - 16,000 acre feet could be satisfied by the proposed offstream reservoir on Corn Cob Canyon (located 3 miles southeast of Watsonville). The annual yield on Corn Cob Canyon could be greater than the projected 9,700 acre feet if upstream sources were less extensively developed than assumed in the State Water Plan. Additional sites which might be developed are given below.

A dam in Chittenden Pass, 4½ miles east of Pajaro could give a storage capacity of about 15,000 acre feet and would undoubtedly yield over 10,000 acre feet/year. Increasing the

size of the dam would inundate the town of Aromas and the cost would probably be prohibitive. Water quality would not be as good in a main stem reservoir because of the inflow of poor quality water during the dry months.

Pescadero Creek, which joins the Pajaro about 1½ miles downstream from the confluence of the San Benito River, is located in a steep canyon which has a suitable location for a dam impounding as much as 70,000 acre feet. Runoff of this stream is not known but it drains an area of about 10 square miles and average runoff would probably exceed 4,000 acre feet/year. This location would be suitable for offstream storage and the diversion from the Pajaro could be pumped from above the confluence of the San Benito River and during a time when water quality was better than average. The yield from the Pajaro would be dependent on the pumping capacity of the diversion pumps as well as on reservoir size and quantity of flow.

2. Hollister-Tres Pinos Sub-basin. M & I usage is predicted to rise to 7,500 acre feet/year by 2060 and the quantity of agricultural water needed after 1980 would remain constant at about 18,000 acre feet/year. This indicates a need for 6,000 acre feet/year by 1980 and 11,000 in 2060.

These demands can be met by in basin development (such as Cienega and San Benito Reservoirs proposed in State Water Plan) provided quality problems can be resolved and cost of development is competitive with other sources. Water quality on the San Benito should be satisfactory for irrigation usage. Quality of water on Tres Pinos Creek is unknown but it may be satisfactory for both M & I and irrigation use. Also, the Pescadero Creek site could be developed to supply the area around San Juan Bautista.

3. Llagas-Uvas Sub-basin. An additional 41,000 acre feet/year will be needed by 1980 and 110,000 by 2060. Even if all of the water flowing past Chittenden (81,000 acre feet/year under ultimate conditions) could be captured it would not be enough to satisfy the projected demand after about 2040 and this would preclude any use of the water in other sub-basins. The demands could be met by local sources until about the year 2020, if 10-15,000 acre feet/year could be developed from surface sources (such as Uvas Creek), if most of the treated urban waste water can be used for irrigation, and if some temporary mining of ground water is acceptable.

Possibly more extensive surface water developments could be made economically in this sub-basin. However, it may not be economical to extensively develop this sub-basin at the expense of the rest of the basin since this would probably be only an interim solution.

TABLE 9

PROPOSED RESERVOIR DEVELOPMENT

(California State Water Plan)

Reservoir	River	Storage Capacity (Acre Feet)	Annual Yield (Acre Feet)
Corn Cob Canyon	Pajaro	21,000	9,700
San Benito	San Benito	50,000	7,000
Cienega	San Benito	40,000	5,300
Enlarged Uvas	Uvas Creek	24,000	6,400
Harper Canyon	Pacheco Creek	65,000 1/	2,000

1/ 53,000 acre feet of storage allocated to South Bay Aqueduct.

SOURCE: State of California Department of Water Resources Bulletin No. 3, "The California Water Plan," May 1957.

4. Upper Pajaro Sub-basin. Increased irrigation is expected to develop a need for 39,000 acre feet/year of new development by 1980. It is doubtful if over 10,000 acre feet/year can be developed economically (Pacheco Creek is the primary source) in this sub-basin so import water will be needed if irrigation increased. Reuse of treated municipal wastes from Llagas-Uvas sub-basin is a possibility although they will not have wastes in excess if their agricultural needs before about the year 2010.

BENEFIT EVALUATION

Municipal and Industrial Water Supply

Studies by several agencies indicate approximate cost of M & I water both by local development and importation. The Corps of Engineers estimates that 7,200 acre feet/year can be developed on Corralitos Creek at about $29.50/acre-foot or 9,800 acre feet/year (at the same site) for $40.70/acre-foot. The California Water Plan estimates that about 28,400 acre feet/year can be developed for an average cost of $31.70/acre-foot (this is adjusted to 1963 construction costs and uses 4% interest for 50 year repayment period). The Bureau of Reclamation proposes to deliver M & I water to the Parjaro River Basin in the San Felipe Project for $30/acre-foot.

Based on the most likely, least cost alternative method of determining the value of benefits, it appears that a value of approximately $30 per acre foot (the cost of imported water) can be used for preliminary planning purposes in assessing the benefits that would be derived from developing additional M & I water from within the Pajaro River Basin. The present annual equivalent benefit (1960) from supplying the additional M & I water needs of the entire Pajaro Basin until 2060 is $1,234,000. As specific local water development projects are recommended, more detailed evaluation of single purpose alternative projects should be made.

Water Quality Control

No tangible water quality control benefits can be assumed for withdrawal users since there is no present or planned withdrawal water use of the Lower Pajaro. There would undoubtedly be some fishery and recreational enhancement but the magnitude of these benefits is not known.

Stream flow regulation benefits, evaluated by the least cost, most likely alternative method of waste disposal, are estimated at $20,240 annually. Based upon an estimated cost of $30 per acre foot for dilution water delivered to the point of need, the value of enhanced downstream water uses would need to exceed $523,000 per annum in 2000 and $2,974,000 per annum in 2060 to economically justify discharge of wastes to the stream combined with stream flow regulation. Downstream enhancement benefits of these magnitudes are not apparent at this time. Also there appears to be no advantage in promoting use of good quality water mixed with treatment plant effluent when a lesser quantity of good water not mixed with effluent will satisfy the projected water requirements. The feasibility of providing water quality control flows as a complete, interim, or partial solution to the waste disposal problem should be re-examined in detail at the time specific resource development projects are proposed.

TABLE 10

FUTURE WATER USES AND NEEDS IN THE PAJARO RIVER BASIN

(Thousand Acre Feet)

Sub-basin	Present Water Development		1960 Water Uses(3)		Future Water Use						Additional Development Needed (M&I + Ag.)			
					1980		2020		2060					
	Safe Annual Ground Water Yield	Surface(1) Sources	M&I	Agri-culture	M&I	Agri-culture	M&I	Agri-culture	M&I	Agri-culture	1960	1980	2020	2060
Llagas - Uvas	68.5	17.5R	4.8	77.2	19.	90.	78.	53.	125.	53.	14	41	63	110
Hollister-Tres Pinos	14.7	0	2.1	14.7	2.8	18.	5.2	18.	7.5	18.	2	6	9	11
Pajaro Valley	38.5	3.0D 3.6S	4.8	42.0	13.	50.	21.	41.	26.	41.	5	22	21	26
Upper Pajaro	37.4	6.1R	0.39	39.4	0.5	76.	0.7	76.	0.9	76.	2	39	39	39
Upper San Benito(2)	--	18.7S	0.14	--	0.2	--	0.3	--	0.3	--	--	--	--	--
TOTAL	159.1		12.2	173.3	36.	234.	105.	188.	160.	188.	23	108	132	186

(1) R = volume of storage (not yield) operated for ground water recharge.
D = quantity of water diverted from stream.
S = volume of storage (not yield) operated to supply surface irrigation water.
Reservoirs under 3,000 acre feet capacity are not included.

(2) Ground water yield and irrigation usage in this basin is not known. It is presumed that future needs can be met by local developments in the sub-basin.

(3) M&I use data is developed in this report. Agriculture quantities and safe ground water yields are from USBR data (San Felipe Project). The Hollister sub-area used in San Felipe Report includes parts of Upper Pajaro, Hollister-Tres Pinos, and Pajaro Valley sub-basins; apportionment made according to present and proposed irrigated acreage. Irrigation use assumed to remain constant after 2020.

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7. Brown and Caldwell Consulting Engineers, "Second Stage Construction Program Treatment, and Disposal of Sewage and Industrial Wastes, City of Watsonville, California," February 1958.

APPENDIX A

WATER USE AND WASTE LOADINGS

Three sets of data were developed to project water use and waste loads:

1. Data on population, employment, vistors and land use density. This data, in a general form, was supplied by the Corps of Engineers.

2. Data on typical water use by type of user.

3. Data on typical waste loads by type of users.

The data furnished by the Corps of Engineers was arranged to tabulate 6 types of water user:

a. Heavy Industry - employment forecasts furnished by the Corps were distributed between heavy and light water use for each sub-basin. Present employment statistics were adjusted using California Department of Employment data.

The present heavy industrial water use for San Jose and Watsonville was investigated by the Bureau of Reclamation (1). Their findings were compared with data collected by the Consulting Engineers of Brown and Caldwell (2) and a general estimate of 2000 gallons per employee day for a 100 day employment period was derived. The important heavy water using industries in the area are food processors, so the water use occurs during the harvesting season.

Waste loadings from heavy industrial water use were estimated from data reported by Brown and Calwell (2) and data developed during a study of other industrial and food processing areas in California (1). A unit pollution load of 3 or 5 lbs of 1st stage BOD per employee day was selected.

1/ U. S. Bureau of Reclamation - San Felipe Div. - Municipal and Industrial Water Appendix, March 1961.

2/ Brown and Caldwell, Consulting Engineers, San Francisco
   a) San Jose Sewage Treatment Study May 1958 - December 1959
   b) Second stage construction Program - Treatment and Disposal of Sewage and Industrial Waste - City of Watsonville, Califonia Supplement of February 1958.

The Pajaro Valley (Watsonville) sub-basin waste load is estimated at 3 lbs/day, the rest of the area at 5 lbs/day. These waste loads occur on a somewhat intermittent basis, although there is some agricultural activity year-round.

b. Light Industry - The remaining portion of industrial employment is distributed to light industry. An average figure for light industrial water use in about 100 gallons per employee per day (gped). Waste loading is estimated at 0.25 lbs of 1st stage BOD per employee per day.

c. Service Employment - An estimate of 20 gad and .03 lbs 1st stage BOD/em/day is used.

d. Visitors - Data on visitor days furnished by the Corps were distributed to sub-basin in proportion to Service employment and Public and Reserved Land areas. A water use of 10 gallons/visitor day is estimated and a waste load of .03 lbs 1st stage BOD/visitor day distributed over a 200 day season (3).

e. Residents - Inside Use - Based on data developed by the Bureau of Reclamation, present water use inside the home (exclusive of lawn irrigation) is estimated at 80 gallons/capita/day, (gpcd). This is less than the Bureau's estimate of 90 gpcd, (4) but their estimates do not include an allowance for visitors and service employment. Future inside water use is estimated to increase to 90 gpcd in 1980 and 100 gpcd in 2000 and beyond. This reflects an increase in water use for garbage grinders, more bathing, increased use of water as an amenity, etc.

Waste loadings are estimated at 0.24 lbs 1st stage BOD/person/day in 1960, 0.27 lbs in 1980 and 0.30 lbs in 2000 and beyond. An assumption of more waste loading per person due to an increase in garbage grinders, etc., caused this projection.

3/ U. S. Public Health Service "San Joaquin Valley and Sacramento - San Joaquin Delta California," June 1963.

4/ U. S. Bureau of Reclamation, "San Felipe Division - Municipal and Industrial Water Appendix," March 1961.

f. Outside Water Use - Lawns and Public Areas - The Bureau of Reclamation estimated outside water use for several areas in the Basin (5). These estimates were compared with the land use estimate of the Corps and a general estimate of 0.7 acre feet per year per acre of residential and commercial land was derived for areas lying in the inner basin, and 0.5 acre feet/year for the Pajaro Valley Sub-basin. These outside water use estimators provide a reasonable balance between inside and outside water use, but are subject to variation and change due to the occurence of droughts or a trend to higher residential land use densities.

The population, employment, visitors and land use data are listed in Table A-1. These data are multiplied by their respective coefficients shown in Table A-2 to get the projections shown in Table A-3 and A-4.

The quantities of waste water which will result from water use is the total water use less the outside water use. This is shown in Table A-3 also.

The waste loads are the peak loads. Lower total waste loads would occur when the food processors are not operating. These are shown as the off peak loads in Table A-4.

5/ U. S. Bureau of Reclamation, "San Felipe Division, - Municipal and Industrial Water Appendix," March 1961.

TABLE A-1

POPULATION PROJECTIONS

PAJARO RIVER BASIN

	Inputs	1960	1980	2000	2020	2040	2060
Llagas Uvas	Heavy Ind. (Emp.)	1,100	2,350	3,100	3,730	2,680	1,500
	Light Ind. (Emp.)	1,751	11,070	28,275	52,970	78,727	89,940
	Service (Emp.)	5,731	23,760	54,718	98,550	141,020	159,840
	Visitors/Yr.	176,000	634,000	1,310,000	1,792,000	2,063,000	2,215,000
	Residential-Inside	26,420	110,000	251,000	450,000	641,000	720,000
	Residential-Outside (Acres)	2,000	7,000	15,000	25,000	35,500	43,000
Pajaro Valley	Heavy Ind. (Emp.)	1,250	2,445	3,048	3,215	3,335	3,196
	Light Ind. (Emp.)	550	2,605	3,582	4,335	4,765	5,464
	Service (Emp.)	4,800	13,170	17,140	19,520	21,000	22,450
	Visitors/Yr.	117,000	316,000	436,000	437,000	425,000	443,000
	Residential-Inside	21,000	56,000	73,000	83,000	89,000	94,000
	Residential-Outside(acres)	4,000	10,000	14,500	17,000	20,000	24,000
Upper Pajaro	Heavy Ind. (Emp.)	50	55	70	75	80	85
	Light Ind. (Emp.)	100	120	153	178	198	222
	Service (Emp.)	390	447	561	635	695	754
	Visitors/Yr.	167,000	460,000	819,000	1,020,000	1,123,000	1,203,000
	Residential-Inside	2,100	2,400	3,000	3,400	3,700	4,000
	Residential-Ouside (Acres)	210	240	300	340	370	400
Hollister-Tres Pinos	Heavy Ind. (Emp.)	600	800	1,080	1,370	1,580	1,660
	Light Ind. (Emp.)	140	199	304	447	577	702
	Service (Emp.)	1,915	2,524	3,494	4,506	5,422	5,992
	Visitors/Yr.	38,000	53,000	77,000	87,000	93,000	112,000
	Residential-Inside	10,280	13,600	18,800	24,200	28,800	31,400
	Residential-Outside (Acres)	1,040	1,260	2,000	2,200	3,000	4,000
Upper San Benito	Heavy Ind. (Emp.)	10	10	15	15	20	20
	Light Ind. (Emp.)	13	19	21	27	27	29
	Service (Emp.)	177	217	261	306	329	352
	Visitors/Yr.	4,000	7,000	18,000	24,000	26,000	27,000
	Residential-Inside Use	830	1,000	1,200	1,400	1,500	1,600
	Residential-Outside (Acres)	83	100	120	140	150	160

TABLE A-2

WATER USE & WASTE LOADING COEFFICIENTS

WATER USE: Area	Heavy Industry	Light Industry	Service	Visitors	Residents Inside	Outside Use
Llagas-Uvas Upper Pajaro Hollister- Tres Pinos Upper San Benito	2000 gal/emp.day for 100 days/year = 0.61 AF/Yr.	100 gal./day = 0.112 AF/Yr.	20 gal/day = 0.0224 AF/Yr.	10 gal/visitor da. = .0000307 AF/Visitor da.	Year 1960 80 gal/day = .0895 AF/Yr. Year 1980 90 gal/day = .1009 AF/Yr. Year & Beyond 2000 100 gal/day = .112 AF/Yr.	0.7 AF/AC/YR
Pajaro Valley	same	same	same	same	same	0.5 AF/AC/YR

WASTE LOADS - 1st Stage BOD:

Area					
Llagas-Uvas Upper Pajaro Hollister- Tres Pinos Upper San Benito	5 lbs/day	0.25 lbs/day	.03 lbs/day	.03 lbs/day over 200 days = .00015 lbs/day	Year 1960 .24 lbs/day Year 1980 .27 lbs/day Year 2000 & Beyond .30 lbs/day
Pajaro Valley	3 lbs/day	same	same	same	same

TABLE A-3
WATER USE CALCULATIONS
(Acre Feet/Year)

		1960	1980	2000	2020	2040	2060
Llagas Uvas	Heavy Ind.	670	1,430	1,890	2,280	1,640	920
	Light Ind.	200	1,240	3,170	5,920	8,810	10,100
	Service	130	530	1,220	2,230	3,160	3,580
	Visitors	5	20	40	55	65	70
	Residential-Inside	2,360	11,100	28,100	50,400	71,900	80,600
	Residential-Outside	1,400	4,900	10,500	17,500	24,800	30,000
	Total	3365/4765	14320/19220	34420/44920	60885/78385	85575/110375	95270/125270
Pajaro Valley	Heavy Ind.	760	1,490	1,860	1,960	2,030	1,950
	Light Ind.	60	290	400	490	530	610
	Service	110	300	380	440	470	500
	Visitors	5	10	15	15	15	15
	Residential-Inside	1,870	5,650	8,180	9,300	9,970	10,530
	Residential-Outside	2,000	5,000	7,250	8,500	10,000	12,000
	Total	7805/4805	7740/12740	10835/18085	12205/20705	13015/23015	13605/25605
Upper Pajaro	Heavy Ind.	30	34	43	46	49	52
	Light Ind.	11	13	17	20	22	25
	Service	9	10	13	14	16	17
	Visitors	5	14	25	31	35	37
	Residential-Inside	188	242	336	380	414	448
	Residential-Outside	147	168	210	238	259	280
	Total	243/390	313/481	434/644	491/729	536/795	579/859
Hollister Tres-Pinos	Heavy Ind.	370	490	660	840	960	1,010
	Light Ind.	16	22	34	50	65	79
	Service	43	57	78	100	120	134
	Visitors	1	2	2	3	3	3
	Residential-Inside	920	1,370	2,100	2,710	3,230	3,520
	Residential-Outside	730	880	1,400	1,540	2,100	2,800
	Total	1350/2080	1941/2821	2874/4274	3703/5243	4378/6478	4746/7546
Upper San Benito	Heavy Ind.	6	6	9	9	12	12
	Light Ind.	1	2	2	3	3	3
	Service	4	5	6	7	7	8
	Visitors	-	-	1	1	1	1
	Residential-Inside	74	101	134	157	168	179
	Residential-Outside	58	70	84	98	105	112
	Total	85/143	114/184	152/236	177/275	191/296	203/315

TABLE A-4
BOD WASTE LOADS
(pounds/day of 1st stage BOD at 20°C)

Area	Category	1960	1980	2000	2020	2040	2060
Llagas Uvas	Heavy Ind.	5,500	11,750	15,500	18,650	13,400	7,500
	Light Ind.	440	2,760	7,060	13,200	19,700	22,400
	Service	170	710	1,640	2,960	4,240	4,790
	Visitors	30	100	200	270	310	330
	Residential	6,350	29,700	75,300	135,000	192,500	216,000
	Totals	6990/12490	33270/45020	84200/99700	151430/170080	216750/230150	243520/251020
Pajaro Valley	Heavy Ind.	3,750	7,340	9,140	9,650	10,000	9,590
	Light Ind.	140	650	900	1,080	1,190	1,370
	Service	140	400	510	590	630	670
	Visitors	20	50	70	70	60	70
	Residential	5,040	15,150	21,900	24,900	26,700	28,200
	Total	5340/9090	7810/23590	23380/32520	26640/36290	28580/38580	30310/39900
Upper Pajaro	Heavy Ind.	250	275	350	375	400	425
	Light Ind.	25	30	40	45	50	55
	Service	10	15	20	20	20	25
	Visitors	25	70	125	150	170	180
	Residential	505	650	900	1,020	1,110	1,200
	Total	565/815	765/1040	1085/1435	1235/1610	1350/1750	1460/1885
Hollister Tres Pinos	Heavy Ind.	3,000	4,000	5,400	6,850	7,900	8,300
	Light Ind.	35	50	75	110	145	175
	Service	60	75	105	135	165	180
	Visitors	5	10	10	15	15	15
	Residential	2,470	3,680	5,640	7,260	8,640	9,420
	Total	2570/5570	3815/7815	5830/11230	7520/14370	8965/16865	9790/18090
Upper San Benito	Heavy Ind.	50	50	75	75	100	100
	Light Ind.	5	5	5	10	10	10
	Service	5	5	10	10	10	10
	Visitors	-	-	-	5	5	5
	Residential	200	270	360	420	450	480
	Total	210/260	280/330	375/450	445/520	475/575	505/605

APPENDIX B

WATER QUALITY CONTROL FLOWS

METHOD OF CALCULATION

As discussed previously dissolved oxygen (DO) requirements are anticipated to be the critical parameter in determining water quality control flows in the Pajaro Basin. It is necessary to calculate the DO present in a stream in order to determine the quantity of dilution water needed.

The quantity of dilution water needed to maintain DO above the minimum allowable in a stream may be calculated by trial and error if values can be determined for the following factors: (1) rate of discharge of sewage or effluent into the stream; (2) its temperature; (3) its Biochemical Oxygen Demand (BOD); (4) its initial DO concentration; (5) the BOD of diluting water in the stream; (6) its temperature; (7) its initial DO; (8) the deoxygenation coefficient of the waste; and (9) the reaeration coefficient of the stream. Some of these factors will vary due to temperature, nature of sewage treatment, and composition of sewage. These calculations assumed an average temperature and DO for winter time conditions and another for summer time conditions, then an average year around flow was determined. These averages were based on records of DO and temperature in the Pajaro at Chittenden. Obviously, this determination can be considered only as an approximation due to the large number of variables as well as the uncertainty in BOD load.

The assumed conditions are listed below:

Summer Temperature:	20°C
Summer Season:	5 months (June-Oct)
Summer DO in Stream:	8.17 milligram per liter (mg/l)
Summer Staturation DO:	9.17 mg/l
Winter Temperature:	15°C
Winter Season:	7 months (Nov-May)
Winter DO in Stream	8.5 mg/l
Saturation DO Winter:	10.15 mg/l
BOD of Stream:	1.0 mg/l (Both seasons)
DO of effluent:	1.0 mg/l
Temperature effluent:	same as stream
Minimum allowable DO in stream:	5.0 mg/l

A portion of the required dilution water can be met by natural flows in the streams. In this basin much of the runoff occurs during storms and even during the wet portion of the year natural flows are

often below 20 cubic feet per second. It was determined that about 35% of the needed water quality control flows can be met by natural flow if only 20 - 30 cfs are needed. If 100 - 150 cfs are needed the natural flows would provide only 20% of the water needed. It seems reasonable to have projected requirements on present stream flow since future flows could be either decreased by upstream developments or increased due to additional irrigation return water. Therefore, these figures are used in determining the cost of water quality control flows.

APPENDIX C

ESTIMATED COST OF THE LEAST COST ALTERNATIVE METHOD OF WASTE TREATMENT AND DISPOSAL

A detailed cost analysis was made to determine the cost of the least cost, most likely, alternative method of municipal and industrial waste treatment and disposal to the Llagas-Uvas and Hollister-Tres Pinos Sub-basins. Primary treatment of wastes combined with pipeline disposal of the effluent to the ocean is considered the least cost, most likely alternative method the communities would select in lieu of secondary treatment, discharge to the Pajaro River and provision of dilution water for quality control. The estimated costs of the alternative, ocean disposal, method of wastes represents the benefits attributable to stream flow regulation.

Since primary treatment is considered adequate for ocean disposal while secondary treatment would be required prior to discharge of the effluent to the Pajaro River, the alternative costs of ocean disposal would consist of the cost of the pipeline and ocean outfall less the additional cost of secondary treatment of the municipal and industrial wastes.

This appendix shows the procedure use in arriving at the cost of ocean disposal as the measure of the benefits attributable to stream flow regulation.

TREATMENT COSTS

Unit sewage treatment costs as referred to in this report reflect the initial installation costs plus the costs of operation, maintenance and replacement. An interest rate of 4 percent was used in developing unit costs of treatment. The engineering News Record Cost Index was assumed to be 1000.

Preliminary, unpublished data from the University of California yield the following formulation for treatment costs for varied plant sizings and efficiencies.

$$\text{Cost: } \$/\text{Acre Foot} = \left(\frac{31}{(S)^{.23}}\right)\left(\frac{1}{(1-T)^{.31}}\right)\left(\frac{ENR}{1000}\right)$$

Where: S = size of plant - mgd
T = Treatment efficiency
ENR = Engineering News Record Cost Index

For the costs developed for comparison of alternative disposal schemes a plant sizing in the 25 mgd range was assumed.

TABLE B-1

UNIT COST OF TREATMENT VERSUS TREATMENT EFFICIENCY

Type of Treatment	5 day BOD removal	Cost of Treatment
Primary Treatment	35%	$17/AF
Secondary Treatment	90%	$30/AF

Primary treatment will be acceptable for disposal through an ocean outfall, while secondary treatment is necessary if wastes are to discharged to the streams.

PIPELINE COSTS

The assumptions made for the pipeline scheme as an alternative method of waste disposal for the Llagas-Uvas sub-basin are outlined in this section. The scheme was sized for the Llagas-Uvas waste flows only, although the much smaller quantity of wastes from the Hollister-Tres Pinos Sub-basin could be transported in a common pipeline without an increase in pipeline size.

The pipe length and slopes were measured from U. S. Geological Survey quadrangle maps along the route taken by the Pajaro River. The wastes were assumed to be discharged from large primary treatment plants in the order of 25 mgd size range to a point near the confluence of the Llagas Creek with the Pajaro Viver. Reinforced concrete pipe, (C-120) was assumed for the terrestrial as well as the ocean outfall.

Pipe costs, in place, were derived for ENR = 1000 based on data contained in a local engineering study (a). Submerged outfall costs were derived from estimating data prepared by a local engineering consultant for a water agency (b).

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a/ Brown and Caldwell, Consulting Engineers, Central Contra Costa Sewerage Survey, 1956.

b/ Creegan and D'Angelo, Estimating Data, Prepared for Santa Clara - Alameda - San Benito Water Authority.

ESTIMATED ANNUAL EQUIVALENT COSTS
1980-2060

Since all waste disposal facilities would be non-federal expense, an interest rate of 4% is used in the following calculations. The costs are for an 80 year period beginning in 1980.

Equivalent Cost of Ocean Disposal

The cost and construction dates used are those discussed above. The annual costs were computed as shown in Table C-1.

Equivalent Cost Difference Between Primary & Secondary Treatment

Since discharge to the stream requires secondary treatment while only primary treatment would be needed for pipeline disposal it is necessary to calculate the cost differences. This comparison assumes that secondary treatment with 90% efficiency costs $30/acre foot and primary treatment costs $17/acre foot, as presented earlier.

The least cost, most likely, alternative method of estimating stream flow regulation benefits shows that benefits would be limited to $20,240 annually as follows:

Estimated Annual Equivalent cost of pipelines	$576,467
Less annual equivalent savings in treatments costs	556,227
Annual Equivalent Value of benefits from stream flow regulation	20,240

The quantity of dilution water required to mitigate the deleterious effects of discharging treatment plant effluent to the Pajaro River is estimated to be 18,000 acre feet annually in 1980, and increasing to 99,800 acre feet annually by 2060. On an acre foot basis the annual benefits attributable to stream flow regulations would be $1.12 per acre foot in 1980 decreasing to $0.20 per acre foot in 2060.

Detailed estimates of costs of providing dilution water for stream flow regulations are not available. The Bureau of Reclamation in their San Felipe Report estimate they could supply water for municipal and industrial purposes in the basin at a price of $30.00 per acre foot. If this price is used to estimate the cost of providing dilution water the total annual cost of the needed water would be $543,000 in 1980 increasing to $2,974,000 annually by 2060. Since these costs greatly exceed the benefits from stream flow regulations, as computed above, the inclusion of storage of water for stream flow regulation in federal storage projects is not recommended at this time. It should, however, be pointed out that if municipal and dustrial wastes, after secondary treatment, were discharged to the Pajaro River and quality of the stream was controlled by the addition of

dilution water the combined flow would provide the opportunity fo future enhanced uses of the stream for both withdrawal and inplace purposes. Current planning of water resource developments in the basin as well as plans for the importation of water by both federal and local agencies, however, do not contemplate the reuse of waters in the lower reach of the Pajaro River.

TABLE C-1

ESTIMATED ANNUAL EQUIVALENT COSTS OF OCEAN DISPOSAL OF MUNICIPAL & INDUSTRIAL WASTES GENERATED IN THE LLAGAS-UVAS & HOLLISTER TRES PINOS SUBAREAS, PAJARO BASIN, CALIFORNIA, 1980-2060

Estimated first pipeline costs (1980)	
Pipeline construction	7,779,000
Ocean outfall	1,426,600
Land Costs	183,000
Present total value (1980) of O & M 9,205,600 x .0025 x 21.482184 =	494,390
Present Value (1980) of Estimated Costs of Second Pipeline (2010)	
Pipeline Construction (2010) 7,779,000 x .308318 =	2,398,406
Present Total value of O & M 7,779,000 x .0025 x 21.482184 x .308318 =	128,811
Present Value (1980) of Estimated Costs of Replacement Pipeline and outfall and lengthen outfall (2030)	
Construction Costs 10,632,200 x .140712	1,496,078
Less present value of remaining service life in 2060 (20 years) 10,632,200 x .40 x .043384	- 184,507
Present total value of O & M for 30 years (2030 to 2060) 10,632,200 x .0025 x 17.292033 x .140712 =	64,674
Total Present Value in 1980 of Pipeline Disposal 1980 to 2060	13,786,452
Annual Equivalent Value in 1980 13,786,452 x .041814	576,467
Annual Equivalent Value in 1964 576,467 x .533908	307,780

Interest Factors Used:

.0025 = Annual O & M costs estimated to be .25 percent of pipeline and outfall costs
21.482184 = Present value of one per year for 50 years
.308318 = Present value of one 30 years hence
.140712 = Present value of one 50 years hence
.043384 = Present value of one 80 years hence
17.292033 = Present value of one per year for 30 years
.041814 = Amortization of one over 80 years
.553908 = Present value of one 16 years hence

TABLE C-2

PRESENT VALUE OF FUTURE DIFFERENCES
IN TREATMENT COSTS

Annual Rate	Quantity of Waste Treated AF/year	Net Difference in Cost Annual Rate	Increase During Period	Discount Factor	Present Annual Equivalent Value (1980)
1980	16,200	$ 210,000	$ 210,000	-	$ 210,000
2000	37,300	485,000	275,000	.69333	190,666
2010	51,000	663,000	178,000	.35705	63,555
2020	64,600	840,000	177,000	.22649	40,089
2030	77,600	1,010,000	261,000	.13829	36,094
2040	90,200	1,170,000	160,000	.07871	12,594
2060	100,000	1,300,000	130,000	.02487	3,229
Present (1980) annual equivalent value of difference in treatment costs					556,227

15

APPENDIX D

GROUND WATER SALT BALANCES 1/

To determine if the quantities of Total Dissolved Solids (salts) are increasing in a ground water basin it is necessary to balance the tons of salt coming into the basin by the tons flowing out. To get an accurate balance it is necessary to know accurately the quantities and concentrations of all waters moving into or out of the basin by surface, sub-surface, and atmospheric paths. A more refined analyses would also include TDS removed by crops and that added by leaching of fertilizers, but on the average these roughly offset each other. Leaching from the soil can also add significant quantities of TDS but this amount is assumed to be negligible under equilibrium conditions.

The inflow and outflow quantities shown in Table E-1 and E-2 are taken from USBR "Ultimate Development" figures (San Felipe Division, Geology and Ground Water Resources Appendix). The concentrations were taken from the limited data available and, in some cases, from assumptions. The accuracy of the answers is uncertain due to the insufficient data and should be considered as examples only.

The following assumptions were made:

1. Ground water outflow at 800 mg/l TDS. Studies on other basins indicated that the "downstream" concentration will be much higher.

2. 2,5000 acre feet/year of Llagas-Uvas Sub-basin ground water flows out the Pajaro also at a concentration of 800 mg/l.

3. The present average TDS concentration of the Pajaro River remains unchanged. This would be a desirable goal, particularly if there is downstream use of the water. Furthermore, it does not appear that water which has percolated to the ground water table reappears in the Pajaro River except for limited outflow during wet years.

4. The increased dissolved solids due to municipal use were not included in the tabulation nor were the solids present in ground water pumped for M & I use. Therefore, if waste effluents remain in the basin the human increment should be added to the inflow. Conversely, if wastes are transported out of the basin the solids in ground water use for M & I should be added to the outflow.

1/ Maron, A., and Ludwig, H.F., "Salt Balances in Ground Water," Proceedings American Society if Civil Engineers, Journal of Sanitary Engineering Division, June 1963.

The tons of salt that must be removed to maintain present water quality is the difference between inflow and outflow.

Llagas-Uvas Sub-basin - Must convey 9,300 tons of salt out of the basin. It is planned to use 37,300 acre feet/year of ground water for irrigation under ultimate conditions. The amount of water whose solids must be conveyed out of the basin is:

(.46) x = 9,300
x = 20,200 Acre Ft/year

Of course the volume of return flow would be much less than this, say about 6,000 acre feet/year. However, it is planned to continue to use a large quantity of ground water for M & I use and if most of the waste water is transported to the ocean it may not be necessary to pipe irrigation return flows out of the basin.

Hollister Area - 31,500 tons of salt must be removed yearly. It is planned to use 67,000 acre feet/year of ground water for agricultural use. The quantity of water whose return flow must be conveyed out of the basin is:

(0.92) x = 31,500
x = 34,300 Acre feet/year

The quantity of return flow might be about 11,000 acre feet/year.

It appears that the export of wastes from this area of both M & I and agricultural use is inevitable. Some of these wastes could be reused for irrigation prior to shipping out of the basin if this is done in a manner which keeps the excess irrigation water from percolating to the ground water table. The safe annual yield will be decreased by keeping this water from percolating so either reuse or more importation would be needed.

TABLE D-1

LLAGAS-UVAS SUB-BASIN
GROUND WATER SALT BALANCE
(USBR Ultimate Conditions)

INFLOW	Flow 10^3 AF/Y	TDS Concentration Tons/AF	mg/l	Salts 10^3Tons	Remarks
Surface	50.0	.20	150	10.0	
Subsurface	14.1	.46	340	6.5	
Rainfall	16.1	.01	7.5	0.1	
Deep Percolation of Semiperched Water	2.7	1.36	1000	3.7	
Anderson Res.	3.0	.20	150	0.6	
Deep Percolation of M & I, Irrigation Water	11.3	.68	500	7.7	
Distribution Losses	8.5	.20	150	1.7	
				30.3	
OUTFLOW					
Subsurface	7.5	1.09	800	8.2	Flows into Hollister ground water table.
Surface	2.5	1.09	800	2.7	Outflow from ground water table.
Pajaro River	22.5	.45	330	10.1	
				21.0	

Annual Gain in Tons of Salt = 30.3 - 21.0 = 9,300 Tons

$$\text{ppm} = \frac{9{,}300 \text{ Tons}}{282{,}000 \text{ Acft Storage } (.00136 \text{ Ton/AF})} \quad \begin{matrix} \text{mg/l} \\ \text{ppm} \end{matrix} = 24 \text{ ppm/year}$$

TABLE D-2

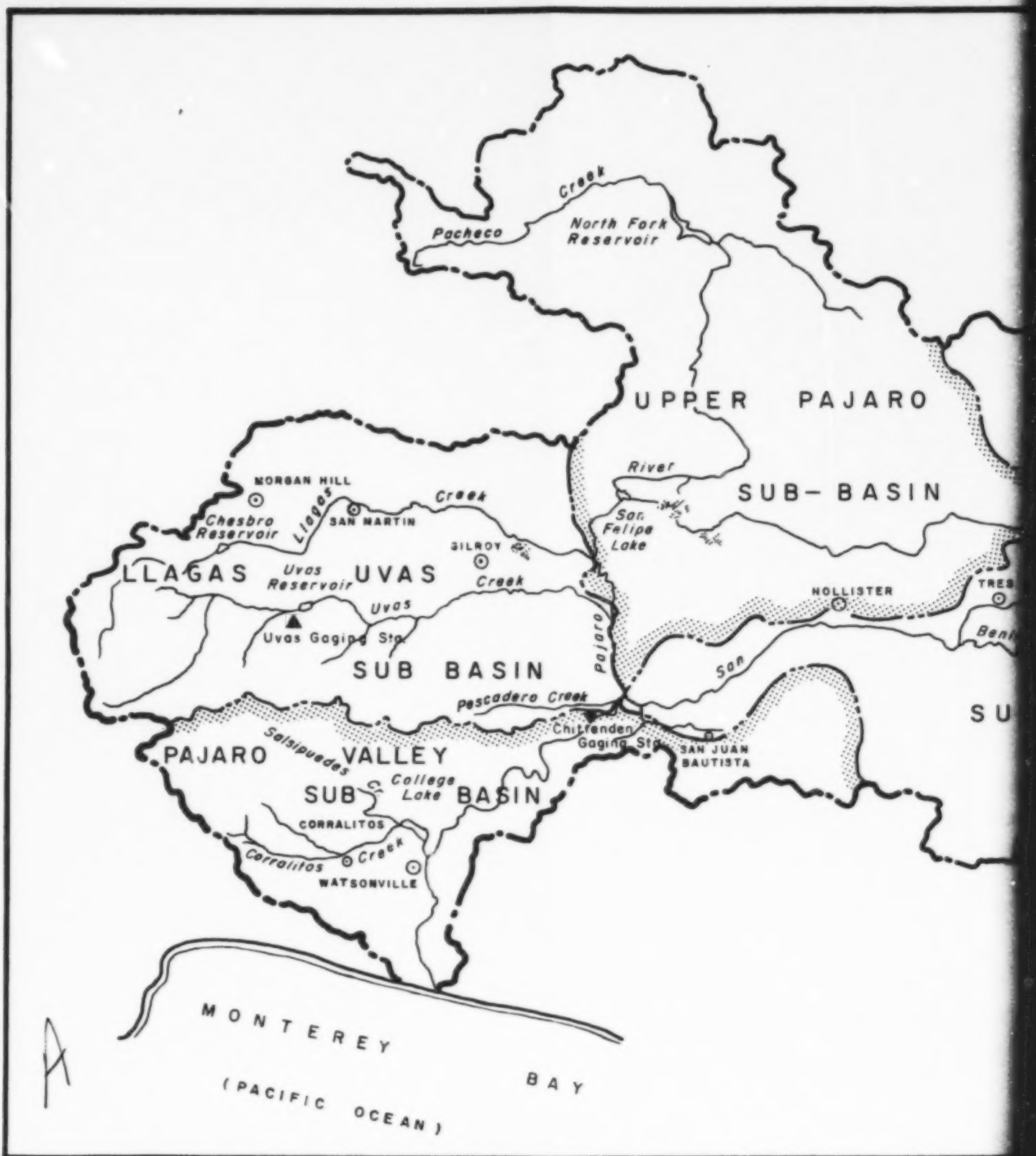
HOLLISTER AREA*
GROUND WATER SALT BALANCE
(USBR Ultimate Conditions)

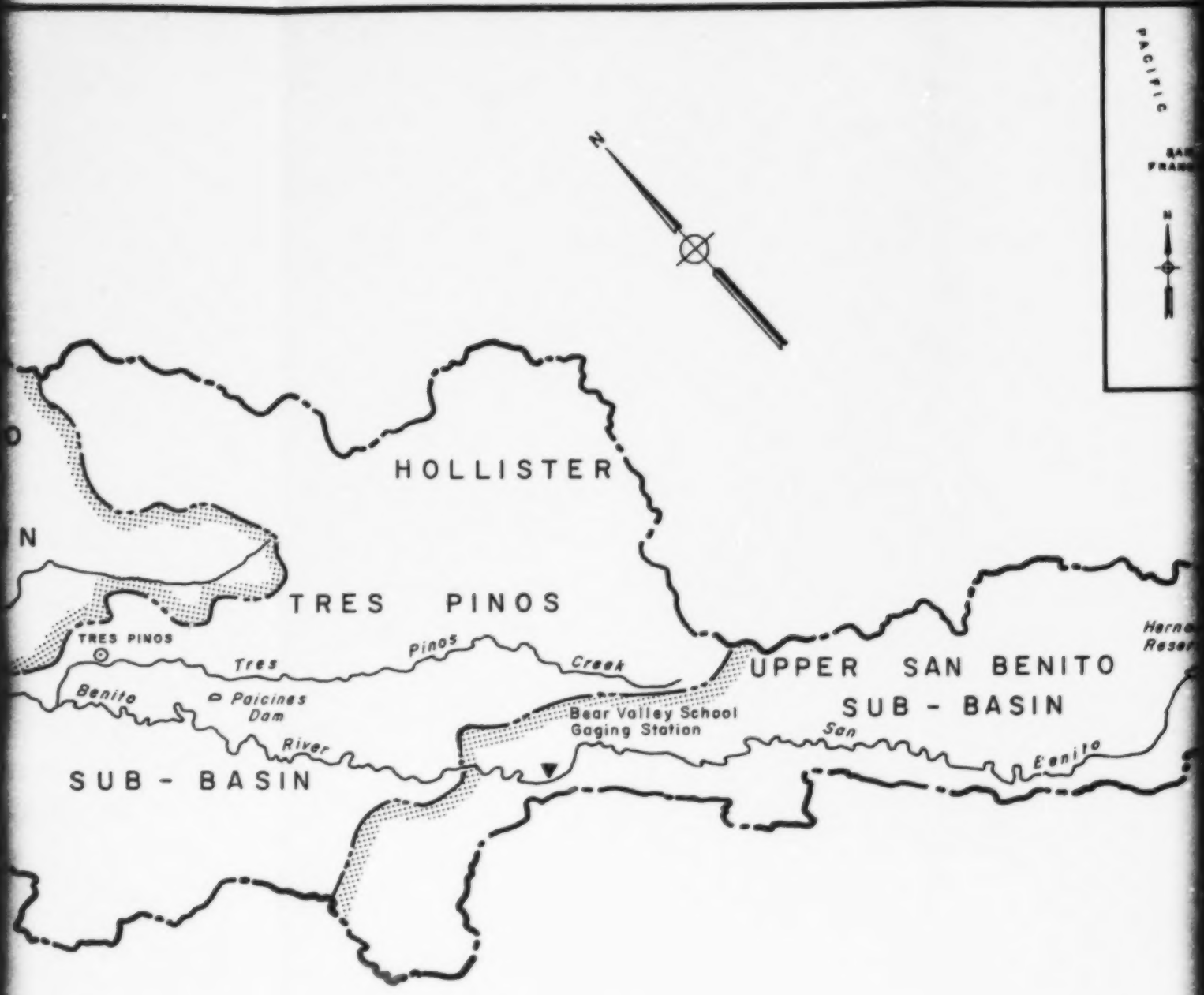
INFLOW	Flow 10^3AF/Y	TDS Concentration Tons/AF	mg/l	Salts 10^3Tons	Remarks
Surface	17	.86	630	14.6	San Benito River
	25	.45	330	11.2	Llagas-Uvas Creeks
	55	.20	150	11.0	Other creeks
Sub-surface	12.5	.81	600	10.2	
	7.5	1.09	800	8.2	From Llagas-Uvas Sub-basin
Precipitation	9.5	.01	7.5	0.1	
Percolated M&I, Ag.	9.9	.68	500	6.7	
Semiperched percolation	2.0	1.36	1000	2.7	
Distribution Losses	5.0	.20	150	1.0	
				65.7	
OUTFLOW					
Pajaro River	76.2	.45	330	34.2	

Annual Gain, Tons of Salt = 65.7 - 34.2 = 31,500 Tons Salt/Year

$$\frac{31,500}{350,000\ (.00136)} = 66 \text{mg/l/year}$$

*This area includes all of Upper Pajaro Sub-basin and that part of Hollister-Tres Pinos Sub-basin north of Tres Pinos Creek's confluence with San Benito River.


Pacheco Creek
North Fork Reservoir
UPPER PAJARO
River
SUB-BASIN
MORGAN HILL
Chesbro Reservoir
Llagas Creek
SAN MARTIN
San Felipe Lake
GILROY
LLAGAS
Uvas Reservoir
UVAS
Creek
Uvas
Uvas Gaging Sta
HOLLISTER
SUB BASIN
Pajaro
San
Pescadero Creek
Chittenden Gaging Sta
SAN JUAN BAUTISTA
PAJARO VALLEY
Salsipuedes Cr.
College Lake
SUB BASIN
CORRALITOS
Corralitos Creek
WATSONVILLE
MONTEREY BAY
(PACIFIC OCEAN)



WATER SUP
PA

DEPARTME
REGION

52

GPO 969-998

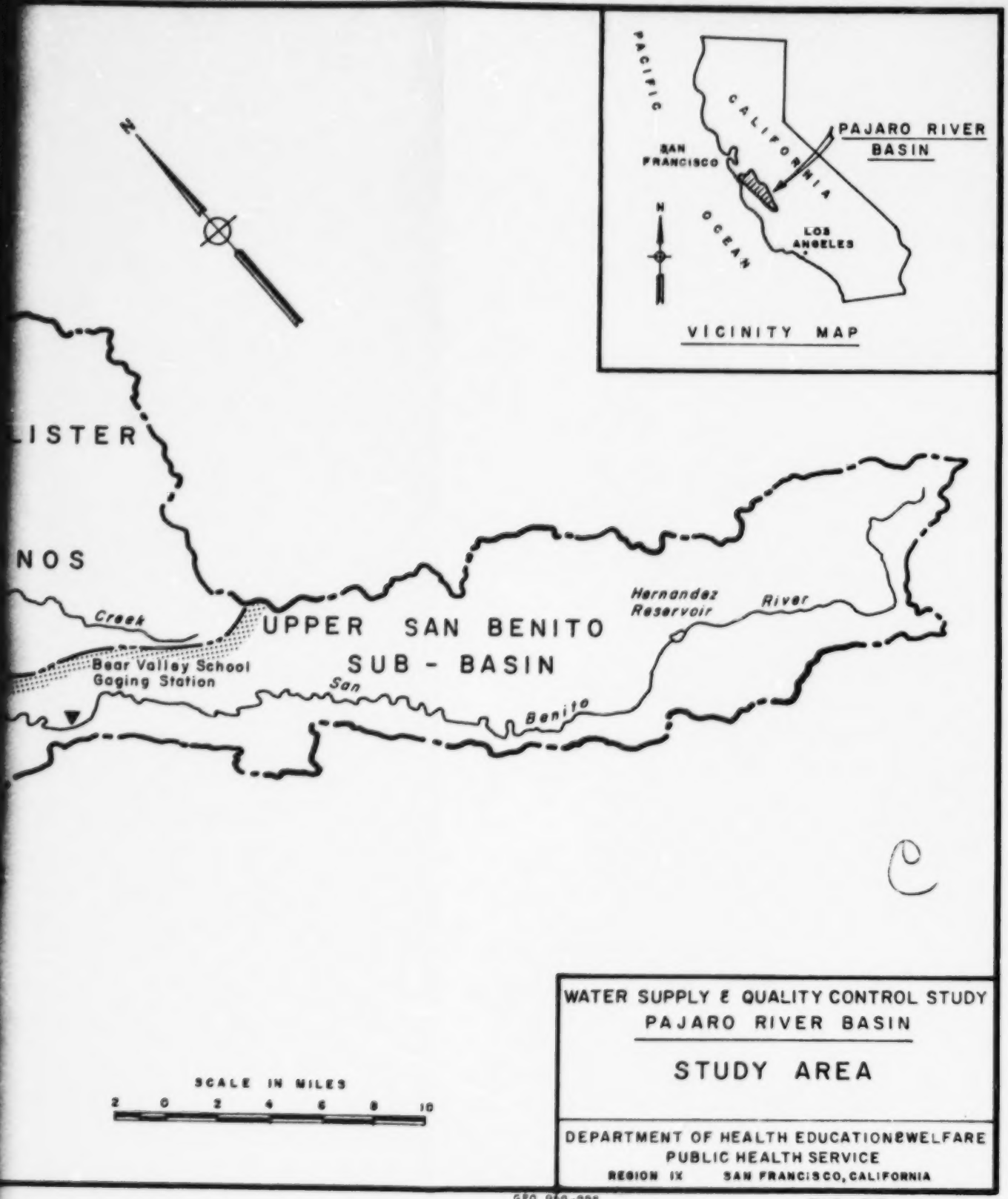


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FIGURE 1